National Centers for Coastal Ocean Science

2003 Annual Accomplishments Report

Message from the Director

The National Centers for Coastal Ocean Science (NCCOS) annual Accomplishments Report for fiscal year 2003 highlights the breadth and range of our scientific activities in support of the nation's coastal ocean resources. While only representing a fraction of the research conducted between October 2002 and September 2003, this report provides an overview of our scientific efforts.

NCCOS provides coastal managers with the scientific resources needed to achieve NOAA's environmental, social, and economic goals. We are determined to see our scientific research extend beyond the laboratory and into the community. Consistent with congressional and executive mandates, NCCOS is committed to achieving academic results and application of our scientific work to local coastal resource managers.

During 2003, our research focused on issues ranging from potential impacts of climate change to risks posed by invasive species, pollution, extreme natural events, and other natural forces stressing our coastal systems. We have also continued to expand our partnerships with public and private interests working on behalf of the nation's coastal ocean resources.

NCCOS has established four goals reflecting the mission and leadership of NOAA and NOAA's National Ocean Service:

- To support coastal managers with the scientific resources needed to preserve coastal ecosystems at sustainable levels;
- To understand and share with our partners how human activities affect coastal ocean ecosystems;
- To improve NOAA's predictive capabilities to minimize social, economic, and ecological impacts of extreme natural events; and
- To be the leader in the environmental stewardship community and the resource "of choice" in coastal ocean science.

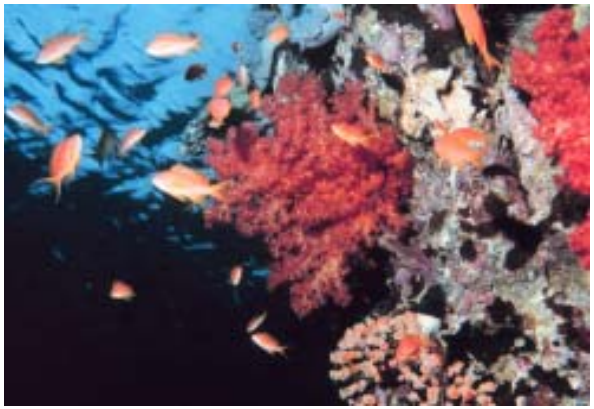
I am delighted to share our progress and achievements of 2003, and how results from this year's activities were put into action to protect our coastal oceans.

We are committed to dynamic, complex, and fascinating work. We encourage your involvement, questions, and above all, your interest in our scientific work. I look forward to an incredible year.

Gary C. Matlock

Gary C. Matlock, Ph.D.

About NCCOS



The National Centers for Coastal Ocean Science (NCCOS) was formed within the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) - National Ocean Service (NOS) in February 1999 as the focal point in NOS for coastal ocean science. NCCOS is comprised of five research centers with specific areas of focus and expertise. Three of the centers have on-site research facilities, while two centers conduct research through analyses of field data or sponsored extramural research.

NCCOS provides leadership through its internal and external research programs linking information technology to the needs of coastal resource managers. NCCOS bridges the gap between science and coastal resource management by applying forecasting capabilities to determine ecological conditions and potential environmental consequences. These capabilities are supported by programs and grants to the academic and private sector to improve public understanding and coastal resource management.

NCCOS' core principles are:

- To deliver accurate science in a timely and consistent manner through innovative and strong partnerships;
- To develop and support relevant research, long-term data collection, analyses, and forecasting capabilities to meet NOAA and NOS objectives;
- To build operational capacity in private, state, tribal, and local sectors by providing information and scientific resources to its customers and partners; and
- To conduct science that identifies, evaluates, and forecasts coastal ecosystem stressors to prevent stressor impacts.

NCCOS focuses its research on four ecosystems: coral reefs; estuaries, including National Estuarine Research Reserves; National Marine Sanctuaries; and coastal ocean regions. Within each ecosystem, emphasis is placed on five stressors: climate change, extreme natural events, pollution, invasive species, and land and resource use.

About NCCOS

NCCOS research provides information on the status of coastal ocean ecosystems as well as the causes and potential consequences of ecosystem changes. This multi-disciplinary research enriches information available to scientists and coastal ecosystem managers by helping them evaluate and compare various management strategies. Most importantly, it puts information and technologies into the hands of communities to protect the health and well being of their citizens and avoid adverse economic impacts resulting from ecosystem damage.

With its federal, state, and academic partners, NCCOS conducts interdisciplinary research on topics of concern to coastal ecosystem managers – from fielding technologies to warn of human health threats, to monitoring for contaminants and invasive species, and evaluating options for protecting endangered habitats. Projects seeking support must successfully compete in a peer-review process to ensure high-level scientific merit and resource management relevance.

Conducting research is the first, but far from the last, step in the ongoing scientific process. Reflecting its goal of providing the scientific tools to protect coastal resources, NCCOS regularly makes its findings available in formats that coastal managers, planners, lawmakers, and the public need for making decisions. For example, NCCOS' integrated assessments help coastal managers and scientists decide among alternative courses of action. Ecological forecasts, another NCCOS tool, help coastal managers predict how physical, chemical, biological, and human-induced ecosystem changes will affect U.S. coastal areas by region and as a whole. It is anticipated that these ecological forecasts will become a trademark of NCCOS' innovative work.

Benefits Nationwide and by Coastal Region

Nationwide...

From the Atlantic to the Pacific, from the Gulf Coast to the Great Lakes, scientists, coastal managers, and residents of U.S. coastal states and territories benefitted from NCCOS research efforts in fiscal year 2003.

Nationwide, NCCOS shared its research findings in authoritative peer-reviewed publications, at professional symposia and workshops, at public meetings, on the Web, and in other venues. This information transfer is critical to advancing the state of knowledge on coastal issues within the scientific community and beyond it to the general public. New modeling and remote sensing technologies developed in NCCOS laboratories help states prepare for impending harmful algal bloom (HAB) landfalls. NCCOS successfully field-tested new instruments and technologies to monitor and detect these HAB events, and to map the physical characteristics and marine life of coastal waters to improve the management of these regions. With its partners on the Aquatic Nuisance Species Task Force, NCCOS developed a plan to help coastal managers control the invasion of the European green crab.

NCCOS and its partners are also developing a multi-volume guidance manual that restoration practitioners, land use planners, scientists, and environmental advocates can use for sound habitat restoration. The draft manual has received strong support from the user community. Uniform nationwide survey programs, such as the Mussel Watch Program that checks the soft parts of mussels and oysters for assorted contaminants, has allowed managers to compare regional conditions against national trends. For example, trends in the Great Lakes indicate that some contaminant levels have declined, though many contaminants still cause concern in the region. In addition, trace element and organic contaminant concentrations at National Estuarine Research Reserves were at or below the median concentration for all Mussel Watch sites.

Benefits Nationwide and by Coastal Region

Along the Atlantic Coast...

In fiscal year 2003, NCCOS scientists advised managers on a range of local issues most important to them. In the northeastern United States, NCCOS helped form a coastal network to leverage monitoring efforts across state boundaries, from Long Island Sound to the Gulf of Maine.

In the Mid-Atlantic states, a newly developed nutrient discharge model is helping coastal managers in Maryland predict changes in the Patuxent River watershed.

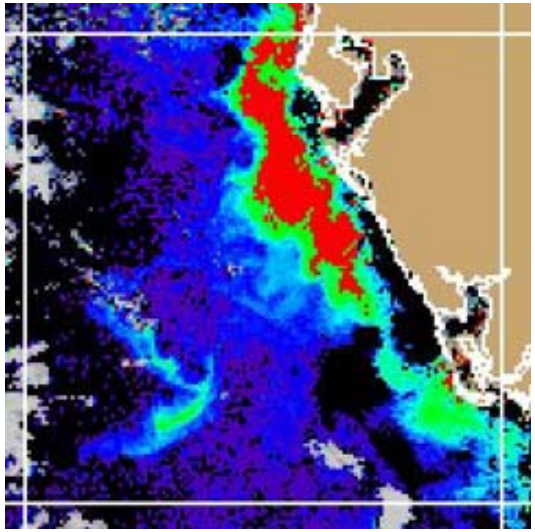
In the southeastern United States, studies are underway in South Florida to help managers predict potential impacts of altered freshwater flows on fish and other protected resources in the Everglades. New mapping technologies to survey fish abundance and composition, coral health, and bottom cover are helping scientists determine the effectiveness of current marine protected area locations and boundaries.

Along the Gulf Coast...

In the Gulf Coast region, one of the most innovative applications of ecological forecasting - the successful prediction of HAB landfalls - is helping monitoring agencies and health departments safeguard public health, local economies, and fisheries. Thirty-nine HAB bulletins published by NCCOS in fiscal year 2003 provided essential advanced warning for landfalls of red tides and other kinds of HABs to Florida's coastal managers, allowing them to better protect public health and natural resources.

In Florida, NCCOS and its research partners are investigating possible links between a recent decline in queen conch reproduction and environmental contaminants, with the results to be included in the region's Queen Conch Fishery Management Plan. Also in the Gulf Coast region, NCCOS-funded studies on hypoxia (i.e., when oxygen levels fall too low to support fish, crustaceans, and other invertebrates) are helping local managers better understand the extent of the problem and what can be done about it. One important NCCOS-supported study published in fiscal year 2003 concluded that current nutrient load reduction targets may not be sufficient to achieve management goals set for reducing the size of the hypoxic zone - the perennial "dead zone" off the coast of Louisiana and parts of Texas.

Benefits Nationwide and by Coastal Region



Along the Pacific Coast...

In 2003, when California experienced the second largest marine mammal mortality event in U.S. history, NCCOS scientists were quick to respond, confirming the presence of domoic acid toxins in tissue samples. This quick response helped the NOAA Fisheries Marine Mammal Stranding Network coordinate the rehabilitation of surviving animals. Newly released information on San Francisco and Monterey Bay contaminants is also helping local managers with pollution abatement projects to clean up and restore vital habitats.

New tools for remote sensing and monitoring of HABs were made available for routine monitoring efforts by states and tribes in California and the Pacific Northwest. In Hawaii, NCCOS and local partners piloted an early warning system for invasive species, a system expected to provide nationwide coverage. The intent of this system is to detect and warn managers before new alien species spread beyond their initial site of introduction.

In American Samoa, NCCOS completed mapping of shallow water benthic habitats, marking successful completion of another milestone in meeting the national goal of mapping all U.S. shallow coral reefs by 2007.

As impressive and wide-ranging as they are, these are just a few of the benefits highlighted in this Accomplishments Report.

Researching Environmental Stressor Impacts on Coastal Ecosystems

There are four ecosystems of interest to NCCOS:

- Coral reefs;
- National Marine Sanctuaries;
- Estuaries, including National Estuarine Research Reserves; and
- Coastal ocean regions.

Coral Reefs

Coral reef ecosystems contribute to biological diversity, fisheries production, coastal protection, tourism, maritime and cultural heritage, and human sustenance. Unfortunately, they are under stress from both natural events (e.g., hurricanes and tropical storms) and human activities (e.g., tourism, fishing, and dredging). Symptoms such as decreases in hard coral covers, proliferation of algae, increases in coral bleaching, and disease outbreaks indicate that almost 60 percent of the world's reefs and the resources they support are at risk. NCCOS is working to meet the national goal of reversing the degradation of U.S. coral reef ecosystems.

National Marine Sanctuaries

National Marine Sanctuaries are areas that have been set aside to maintain the integrity of their unique natural and cultural resources. They include everything from the breeding and feeding grounds of marine animals, to significant coral reefs, kelp forest habitats, and the remains of a sunken historic Civil War ironclad. There are currently thirteen sanctuaries, found in both the Pacific and Atlantic Oceans, off the coast of American Samoa, and in the Great Lakes. NCCOS is partnering with various sanctuaries to determine their overall status, achieve their preservation objectives, and examine the alternative management actions on sanctuary ecosystems.

Researching Environmental Stressor Impacts on Coastal Ecosystems

Estuaries

Approximately 10,900,000 hectares of the U.S. coastline is defined as an estuary - a semi-enclosed coastal body of water, with a salinity gradient measurable from its freshwater drainage to its ocean entrance. Bay and estuarine systems are among the most productive ecosystems on Earth, however, many estuarine systems are experiencing a decline in productivity. NCCOS is currently working to check the status of the Nations estuaries, understand the factors involved in any decline, and develop methods to restore estuarine habitats.

National Estuarine Research Reserves

The goal of the National Estuarine Research Reserve System (NERRS) is to fulfill NOAA's mission in sustaining healthy coasts by improving the nation's understanding and stewardship of estuaries. Established by the Coastal Zone Management Act of 1972, NERRS currently consists of 25 protected estuarine areas representing different biogeographic regions nationwide. The NERRS estuaries, a subset of the nation's estuaries, are "living laboratories" in which scientists conduct research and educators communicate the results. NCCOS' research is directed at determining the status of each reserve, and modeling the structure and function of estuarine ecosystem components and effects of management actions on the estuaries.

Coastal Ocean Regions

For NCCOS, the coastal ocean area is equivalent to the Exclusive Economic Zone (EEZ). The EEZ extends 200 nautical miles offshore and encompasses diverse ecosystems and vast natural resources, such as fisheries and mineral resources. The U.S. EEZ is the largest in the world, spanning over 13,000 miles of coastline - larger than the combined land area of the fifty states. NCCOS' research is directed at protecting coastal resources and the effects of management actions on these regions.

Researching Environmental Stressor Impacts on Coastal Ecosystems

Ecosystems are prone to the effects of variable conditions known as "stressors." NCCOS studies the impact of natural and anthropogenic stressors on the previously-discussed ecosystems. Research conducted by NCCOS and its partners on these stressors, both individually and in combination, provides coastal managers with science to support management decisions they must make about monitoring, controls, and remediation. These stressors can be grouped into five categories:

- Climate change;
- Extreme natural events;
- Pollution;
- Invasive species; and
- Land and resource use.

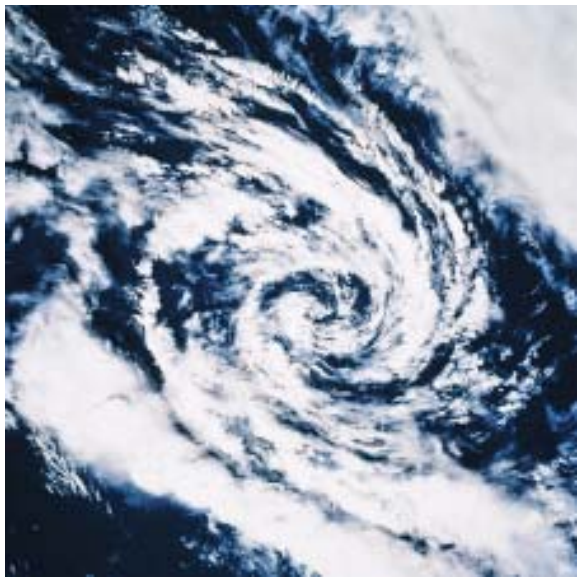
Climate Change

Climate change, both naturally occurring and resulting from human activities, renders coastal ecosystems more vulnerable to risks posed by other stressors. The combined effects of rising sea level and land subsidence, for instance, threaten wetland functions and the sustainability of coastal communities. These conditions have the potential to impair wetland functions as nurseries for fish propagation, harm coral reefs and shellfish beds, and alter the composition of local fauna.

Corals, wetlands, and estuaries already are increasingly stressed from the combined effects of climate change and human activities. However, much uncertainty remains on how coastal zones and marine life will react to ongoing climate change. Observed climate impacts on today's coastal zones and marine life provide useful insights about potential longer-term impacts of climate change and climate variability.

Those engaged in fisheries management, conservation of protected species, environmental protection, and public education activities are among the primary beneficiaries of better understanding of the interactions among oceanography, climate, and food webs. Sharing scientific understanding with coastal managers is at the heart of

Researching Environmental Stressor Impacts on Coastal Ecosystems



NCCOS' goals. Moreover, it capitalizes on NCCOS' primary capability of conducting coastal ocean research, and it underscores the NCCOS commitment to assuring its scientific information and tools help coastal managers meet their resource management goals.

Extreme Natural Events

Extreme natural events like hurricanes, coastal storms, floods, droughts, and HABs can damage coastal communities and produce profound ecosystem changes. For instance, strong winds and waves associated with storms can degrade habitats by altering freshwater flow and nutrient concentrations. They can also lead to more pollution as a result of increased runoff.

Weather may also influence the frequency, severity, and duration of HABs due to the increase in nutrient runoff from land. These events occur in the waters of nearly every coastal and Great Lakes state, and HABs have been responsible for an estimated $1 billion in economic losses over the past few decades. Furthermore, HABs can damage the health of people and marine organisms. These blooms have decimated the scallop fishery in Long Island's estuaries and have led to seasonal closures of various shellfisheries on Georges Bank, from North Carolina to Louisiana, and throughout the Pacific Northwest. They may also have contributed to deaths of hundreds of manatees in Florida, sea lions in California, and other marine mammals, including dolphins in the Northern Gulf of Mexico. HABs have also caused significant respiratory and other illnesses in coastal residents and vacationers. NCCOS' improved methods for forecasting and monitoring for HABs and other extreme natural events are protecting human health and reducing other HAB-related impacts on coastal communities.

Researching Environmental Stressor Impacts on Coastal Ecosystems

Pollution

Pollution - in the form of excess nutrient runoff and land-based chemical discharges from industrial, urban, and agricultural activities - remains a top concern for environmental and land managers in coastal areas. Marine organisms can accumulate contaminants in their tissues from water, sediments, and food. Nutrient pollution, the most widespread pollution problem facing U.S. coastal waters, links a wide array of problems along the nation's coastlines, including:

- Eutrophication;
- Harmful algal blooms;
- Hypoxic areas or "dead zones";
- Fish kills;
- Loss of seagrass and kelp beds; and
- Coral reef destruction.

Land-based discharges of chemical contaminants can degrade surface waters, sediments, and other components of coastal habitats, posing risks to human health and natural resources. These discharges include naturally occurring chemicals like trace metals and oils present in much higher quantities because of human activities, and compounds like pesticides and pharmaceuticals that did not exist in nature until manufactured by humans. Toxic pollutants of particular concern are those that are widespread and persist in the environment, often referred to as persistent organic pollutants. These chemicals tend to accumulate in biological tissues, and in some cases are known to produce biological effects even at extremely low concentrations. NCCOS' research is helping coastal managers decide how to allocate scarce resources to most effectively control and mitigate pollution.

Researching Environmental Stressor Impacts on Coastal Ecosystems

Invasive Species

Invasive species - plants and animals brought to the U.S. from other countries or relocated to new areas within the U.S. - can damage or provide competition for native plants and animals. Invasive species can change the community structure of organisms within an area and cause substantial economic and environmental damage. Causes of invasive species introduction include expanded global trade, the harvesting of exotic marine species to satisfy the increasingly popular aquarium industry, and use of non-native species as agents in agriculture and pest control. Invasive species are also introduced into the marine coastal environment when large ships discharge their ballast water.

NCCOS' invasive species research and monitoring activities are providing an early "heads up" about emerging invasions so coastal managers can prevent the spread beyond the point of initial introduction. NCCOS research is also helping coastal managers develop the most effective localized strategies for prevention and control.

Land and Resource Use

Changes in land and resource use result from increasing demands of a growing population for food and space. America's coastal areas are the most densely populated regions of the country, with a population density five times that found in the country's interior. The resulting impervious surfaces associated with development, such as highways, parking lots, and roof tops, can lead to degraded creeks, marshes, and estuaries.

Populations of edible fish can be reduced, natural habitats damaged or destroyed, and water pollution increased as more chemicals and sediments run off from the land after storms. These conditions are found throughout the coastal U.S. and are among the most challenging problems facing coastal managers. NCCOS research on the effects of land and resource use on coastal ecosystems is helping coastal managers make more informed choices among coastal development options and the most cost-effective measures for protection and restoration.

Climate Change Research: Overview

Managing potential adverse effects of climate change requires a multi-disciplinary effort. NCCOS scientists and partners are studying the combined effects of human-induced and climate-related stresses to understand and predict how critical coastal ecosystems may respond. Three kinds of changes are of particular concern:

- Changes in relative sea-level and coastal storms on the sustainability of coastal communities and wetlands;
- Changes in precipitation and freshwater flow, resulting changes in nutrient delivery and salinity, and implications for management of coastal eutrophication and coastal resources; and
- Changes in ocean temperature, circulation, and carbon dioxide as they might affect the sustainability of coral ecosystems and other sensitive environments as well as species composition in coastal areas.

In fiscal year 2003, NCCOS researchers examined the effects of climate change on fisheries production in the eastern North Pacific and Gulf of Maine. They documented the relationship between climate variability and Gulf of Mexico hypoxia events, and shared their findings at regional workshops.

Climate Change Research: Highlights

GLOBEC Researchers Document Unexpectedly Cool Waters in California Current

The Global Ocean Ecosystem Dynamics (GLOBEC) Program is a multi-year interdisciplinary research effort examining the effects of environmental variability such as climate change on fisheries. Research vessels from the NCCOS-funded GLOBEC Northeast Pacific Program took to the field for the second season in 2003 to examine effects of climate variability and climate change on the distribution, abundance, and production of marine animals - including salmon - in the eastern North Pacific.

GLOBEC researchers from Oregon State University have been sampling the northern California Current off Oregon five times each year since 1997. Results from the 2002 field season show that subsurface upper-ocean waters off Oregon and Vancouver Island were about one degree Celsius cooler in July 2002 than in July 2001. The ecosystem implications of such a change include increased productivity as a result of enhanced nutrient concentrations, and transport and expansion of subarctic species into this region. Hypoxic conditons occurred in bottom waters, as excess phytoplankton sank and decomposed. Inner shelf hypoxia was accompanied by massive crab and fish kills. Such NCCOS findings provide coastal managers with valuable insights into potential consequences of temperature changes that may be associated with climate change and ocean variability.

Importance of Nutrient Concentrations and Climate Variability for Delivery of Nutrients to the Northern Gulf of Mexico

NCCOS continues to support long-term monitoring and research on the areal extent and potential environmental consequences of the large hypoxic zone off the mouth of the Mississippi River. The delivery of nutrient-rich waters to the northern Gulf of Mexico from the Mississippi River system is a major factor in the development of seasonal hypoxia over the Louisiana continental shelf.

As part of NCCOS-funded studies on hypoxia, scientists from Louisiana State University and the Louisiana Universities Marine Consortium quantified the importance of both increased nitrate concentration and increased river discharge to the

flux of nitrate to the northern Gulf of Mexico. The scientists concluded that a historical increase in the anthropogenic nutrient inputs has had more impact on the lower Mississippi River nitrate flux than climate-induced changes in the discharge rate. They noted, however, that the influence of climatic factors on nitrate flux has been significant, and that it may further increase as a result of global climate change.

Because of the importance of nitrate for the productivity of coastal phytoplankton, future climate change may have important implications for coastal marine eutrophication and hypoxia. This is another issue that NCCOS scientists and partners will be watching closely.

Climate Change Research: Highlights

Extreme Natural Events Research: Overview

Extreme natural events such as hurricanes and HABs, or "red tides," can pose particular risks to coastal oceans and communities. Better forecasting and monitoring methods are critical to protecting human health and lives and lessening the trauma to coastal communities. NCCOS research activities in this area are intended to serve needs that arise not only in emergency responses, but also to improve long-term planning to mitigate future adverse impacts.

In fiscal year 2003, NCCOS scientists worked to understand how large changes in runoff quantities, the timing of extreme events, and the nature and extent of resulting physical damages affect coastal ecosystems over the short- and long-term.

NCCOS researchers in North Carolina's Albemarle-Pamlico Sound, for instance, observed that hurricanes can trigger higher concentrations of chlorophyll and dissolved organic matter. Researchers found differences in the way North Carolina's estuaries responded ecologically to severe storms. The long-term consequences of these changes have yet to be determined. NCCOS also researched hypoxia and hurricane effects on larval fish vertical distributions in the northern Gulf of Mexico and pesticide risks to estuarine systems.

Storms appeared to have a significant effect on the Gulf of Mexico hypoxic zone. NCCOS-sponsored researchers in Louisiana found the hypoxic "dead zone" to be half the size of the usual summer average for the past ten years, likely the result of two large storms that passed through the area. In addition, a team of NCCOS-supported scientists worked to improve ecological forecasting capabilities, leading in 2003 to the first-ever NCCOS forecast of the "dead zone" off the Louisiana and Texas coasts. These recent ecological modeling improvements have also indicated that nutrient load reductions beyond those suggested by the current Gulf of Mexico Action Plan may be necessary to achieve the management goal of reducing the dead zone by two-thirds. These new modeling capabilities are examples of the leading edge of ecological forecasting, a growing NOAA capability critical to coastal management decisions.

Extreme Natural Events Research: Overview

In addition to large-scale and global research efforts, NCCOS is conducting more localized research. One recent study in South Carolina, for example, looked at the potential migration of HABs from retention ponds adjacent to housing developments and golf courses. NCCOS scientists are testing and refining technologies for reliable, cost-effective detection and monitoring of harmful algal species and their toxins. Consistent with its goal of helping coastal managers maintain ecosystems at sustainable levels, NCCOS is making these tools available to coastal states and tribes in several U.S. regions.

NCCOS also provides technical assistance for especially complex analyses. The NCCOS Analytical Response Team, for example, uses highly sophisticated instruments and techniques to provide timely analytical support on unusual mortality events such as marine mammal die-offs and human illnesses associated with HABs. In fiscal year 2003, the Team helped NOAA Fisheries experts determine the causes of unexplained whale deaths in Georges Bank by examining samples of dead whales and their prey for the presence of saxitoxin and domoic acid, toxins associated with some HABs. Off California's Channel Islands, hundreds of dead sea lion fetuses were reported at the same time as the domoic acid-producing diatom was blooming. NCCOS research implicated the domoic acid as the cause of reproductive failure in these sea lions.

In fiscal year 2003, NCCOS laboratories focused on two key aspects of effective HAB management - the need for sensitive, toxin-specific assays and toxin standards for research and field application, and improved understanding of how the physiology of these organisms affects toxin movement through the food web. This research has offered insights into the chemical structures of some key HAB toxins; helped to develop toxin- and species-specific detection probes; helped to increase understanding of the biophysical processes that control red tides; and led to improved understanding of the physiology and environmental toxicity of *Pfiesteria* species.

Extreme Natural Events Research: Highlights

Hurricanes: Timing Affects Severity of Consequences

In 2003, NCCOS scientists completed their initial analysis of the effects of hurricanes on a local ecosystem to better understand future fisheries abundance. They found that changes in distribution and abundance of chlorophyll and colored dissolved organic matter (CDOM) occurred in the Albemarle-Pamlico Sound, North Carolina after a series of three hurricanes in the late summer and early fall of 1999. The increased chlorophyll abundance resulted in the wake of the hurricane-induced flooding, and it did not return to pre-flood levels for more than a year. The research was a joint effort with the National Air and Space Administration (NASA), using an airborne LIDAR sensor to determine the potential long-term impacts of the severe storms, and when a large estuarine ecosystem would recover pre-flood patterns of chlorophyll and CDOM distribution. A valuable "lesson learned" from this research expands on the general understanding that timing of extreme events can greatly influence the magnitude of those effects.

Accurate Identification of *Pfisteria* Critical to Risk Assessment

The HAB dinoflagellate *Pfiesteria piscicida* and five *Pfiesteria*-like organisms known to occur in conjunction with *Pfiesteria* can now be definitively distinguished from each other by analyzing various components through a sophisticated technique. NCCOS researchers and scientists from the Virginia Institute of Marine Science and the Florida Marine Research Institute, developers of the new tool, use polymerase chain reaction assays to make these important distinctions, which will allow for more accurate monitoring for *Pfiesteria piscicida*, better estimates of exposure, improved risk assessments, and better use of finite resources. This new NCCOS tool was featured in an article in the *Journal of Phycology*.

Early HAB Detection Tool Advances Warning Time for Coastal Managers

NCCOS supported the development of a new algal toxin detector that opens the way for assessment of public health impacts of HABs. NOAA and Quileute Tribe scientists are continuing to refine an existing detection method adapted from proven biomedical technology to determine the presence of low levels of the harmful algal toxin domoic acid in seawater and shellfish tissue. The technique being

developed, known as Enzyme-Linked Immunosorbent Assay (ELISA), provides a sensitivity level far below domoic acid levels currently used to close shellfish beds or suspend crab harvesting. A portable version of the ELISA is in development and will bring the test "off the bench" and into the field. For the first time, resource managers will have the ability to collect data in real-time on sublethal levels of the toxin, which should allow for more lead time in determining whether to issue public health warnings to at-risk human populations, enabling them to better serve those groups.

New HAB Detection Tool Differentiates HAB Species

Another HAB tool developed by NCCOS scientists permits detection of the dinoflagellate *Karenia brevis*, a HAB species. Diagnostic photo pigment analysis is used to determine the presence and relative abundance of algal groups in natural phytoplankton assemblages. This approach is especially useful when a genus has an unusual or unique photo pigment composition, such as *Karenia brevis*, which shares a diagnostic pigment with only a few other dinoflagellates. This pigment-based approach provides a useful tool for resolving spatial and temporal distributions of phytoplankton in the presence of *Karenia brevis* blooms and serves as the basis for photodetection of this species. In addition, the advent of fiber optics technology allows detection of even small amounts of pigment.

HAB Diagnostic Tools Solve Mystery of Marine Mammal Mortality Events

NCCOS provides routine emergency support to NOAA Fisheries during marine mortality events. In 2003, NCCOS scientists conducted the first-time identification of the marine biotoxin domoic acid in a whale mortality event off the Massachusetts coast on Georges Bank which expanded the threat of harmful algae in the North Atlantic. Between June 17 and July 30, 2003, several species of whales were found dead in open waters near Georges Bank. Tissues and fluid samples collected by the NOAA Fisheries Marine Mammal Stranding Network were transferred to the NCCOS Analytical Response Team. Diatoms from the domoic acid-producing genus, *Pseudo-nitzschia*, were identified, and high levels of the neurotoxin domoic acid were confirmed by receptor assay and LC-mass spectrometry. The finding is the first documentation of domoic acid in the northeastern U.S. and provides more evidence that the range of HAB impacts may exceed current estimates.

Extreme Natural Events Research: Highlights

Autonomous Underwater Vehicles Provide New Capability for Forecasting HAB Events

NCCOS scientists began exploring the potential of winged autonomous underwater vehicles (AUVs) to serve as sentinels for Florida HAB monitoring and forecasting. In 2003, *Nature* magazine (online) highlighted activities of an innovative NCCOS project using winged underwater vehicles ("gliders") to help forecast and monitor toxic blooms of the reddish plankton *Karenia brevis* off the Florida coast. Red tides resulting from this organism can last up to 18 months and pose risks to thousands of residents and tourists through exposure to toxic aerosols and contamination of shellfish. The gliders gather temperature, salinity, and plankton data at unprecedented spatial and temporal resolutions. The data is then combined with information from ships and satellites to alert coastal communities to impending bloom events.

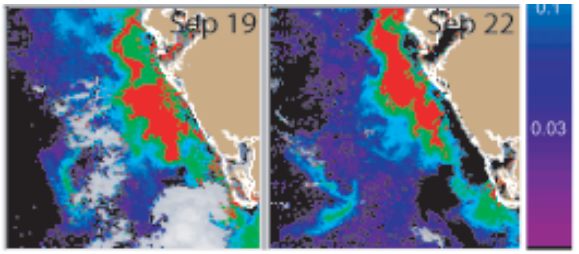
Optical Technology on AUVs Increases Capabilities to Forecast and Monitor HAB Events

Similarly, NCCOS scientists in 2003 for the first time deployed newly developed optical detection technology on AUVs to detect HABs, including the organism responsible for red tides off the Florida coast. Such monitoring, forecasting, and detection capabilities help protect public health and economic interests in the growing number of areas affected by HABs.

NCCOS Research Results in Operational Forecasts of HAB Events

NCCOS research led to the publication of routine bulletins to aid HAB monitoring efforts along the Gulf Coast. In fiscal year 2003, NCCOS released 39 bulletins predicting HAB landfalls in the eastern Gulf of Mexico. One species of concern, the dinoflagellate *Karenia brevis*, produces toxic substances that can cause neurotoxic shellfish poisoning. Risks to humans include respiratory irritations and severe gastrointestinal and neurological symptoms when consumed, though full recovery usually occurs within seven days. NCCOS scientists can locate blooms by assessing surface chlorophyll concentrations detected by satellite imagery and verified by data from ships. They then apply their understanding of biological and physical aspects of bloom dynamics and transport as well as conditions conducive to HAB development to predict when and where HABs will affect coastal communities. These predictions help resource managers, industry, and the public provide advance warnings to prepare and mitigate harmful impacts of HABs.

Extreme Natural Events Research: Highlights



Pollution Research: Overview

Over the past three decades, the U.S. has made substantial progress in reducing water pollution from industrial and municipal facilities. But control of what is called "nonpoint" pollution - such as nutrient, bacterial, and chemical pollution from agricultural fields and urban areas - remains a continuing challenge. NCCOS scientists and their partners in government, academia, and industry are seeking ways to better understand links between nutrient over-enrichment and eutrophication and their impacts on human health and estuaries. A NCCOS-sponsored study found that human-induced nutrient loading is altering nitrogen, phosphorous, and silicate levels and ratios, which may significantly affect the composition of aquatic food webs and increase the frequency of HABs.

Because anthropogenic nitrogen loadings from the Mississippi River to the Gulf of Mexico have increased dramatically during the past several decades, many changes in the ecosystem of the northern Gulf of Mexico have occurred, including the annual development of an extensive zone of hypoxic bottom water during the summer stratified period. Scientists and policy makers have paid significant attention to the evolution and management of hypoxia in the northern Gulf of Mexico because of the enormous size of the hypoxic zone and its implications for watershed management of more than 40 percent of the continental U.S. In recent years, low-oxygen water masses have seasonally covered more than 20,000 square kilometers over the Louisiana continental shelf. Fish and shrimp are almost completely absent from these waters, further heightening the interest in better predicting the causes and consequences of this phenomenon.

NCCOS has compiled historical data on contaminant levels in many estuaries in the U.S. Using sophisticated geographic information systems (GIS) software tools, NCCOS applies the results of historical and current contaminant studies to determine relationships between land use and contaminant levels in estuaries.

A number of ongoing NCCOS research activities are aimed at providing more accurate and cost-effective methods to address chemical contaminants in coastal watersheds. These have resulted in new methods to assess pesticide concentrations in water and risks from pesticides in runoff after large coastal storms, as well as improved ways to analyze the chemical content of sediments. New predictive

models are being used to assess risk to marine species from exposure to pollutants such as organochlorine and mercury.

NCCOS has numerous studies underway to assess regional impacts of particular contaminants. In the Chesapeake Bay region, NCCOS research is examining the presence, levels, and spatial extent of brominated flame retardants (BFRs) and alkyl phenol ethoxylates (APEs) – two groups of contaminants emerging as chemicals of concern in that region.

In Florida's St. Lucie Estuary, NCCOS is examining causes and consequences of observed contamination. The St. Lucie Estuary study is looking at whether there is a link between effluent discharge from freshwater canals and incidence of fish abnormalities and disease that appear to be among the highest observed in U.S. waters. The study is expected to lead to new recommendations for preserving the estuary's environment and resources.

Several NCCOS studies performed with estuarine grass shrimp have found toxic effects from chronic exposure to certain chemicals - among them the commonly used fungicide chlorothalonil and insecticide fipronil. Use of fipronil, warns one NCCOS study, should be carefully monitored to prevent adverse impacts.

Pollution Research: Overview

Pollution Research: Highlights

Point Source Pollution Still Problematic for Northeast Estuaries

NCCOS scientists and its partners analyzed data on nitrogen loading and their sources around the northeast U.S. They found that for the northeast, much of the nitrogen in large estuaries comes from wastewater treatment plant discharges. According to the study, atmospheric and agricultural pollution play lesser roles in nitrogen deposits in the region. The study, which was organized by the Hubbard Brook Research Foundation, synthesized existing data on nitrogen pollution in estuarine and forested ecosystems in New York and New England. The team of scientists conducted biogeochemical modeling studies to analyze how various strategies work in reducing effects of nitrogen pollution. Model predictions indicate that management strategies that target several sources may be the most effective in reducing the adverse effects of nitrogen on estuaries. The results of the study were published in a paper entitled, "Nitrogen Pollution: Sources and Consequences in the U.S. Northeast" and described in the September 2003 issue of the journal *Environment*.

Increasing Copper Concentrations in Florida Estuary Causing Concern

NCCOS studied sources of chemical loading in the St. Lucie Estuary in Florida. Data collected by NCCOS scientists show high levels of copper and mercury in sediment of the North Fork of the St. Lucie Estuary, and an increasing trend in copper concentration in bivalves in the Indian River Lagoon. Copper is used extensively (i.e., more than two million pounds per year) on grapefruit and orange trees and tomatoes to control melanose, a fungal infection. As a likely consequence of copper use in citrus groves, copper is being detected in increasing amounts in nearly all rivers, tributaries, and canals that discharge into the estuaries. Within those estuaries, copper could also be leaching in substantial amounts from antifouling paint used to prevent buildups on boat hulls. Further research will focus on determining biological effects of copper, and on modeling to describe sources, transport, and likely effects of copper on the estuarine environment and resources.

Pollution Research: Highlights

Model Predicts Mercury Concentrations in Fish

In 2003, another NCCOS research effort on contaminants sought to answer the question, "why do some fish have so much mercury?" Mercury concentrations in some coastal pelagic fish exceed the one part-per-million concentration consumption limit established by the U.S. Food and Drug Administration (FDA). Blue marlin samples collected from fishing tournaments in North Carolina by NCCOS and Duke University Marine Laboratory scientists had mercury concentrations of up to 17 parts per million. By contrast, yellowfin tuna and mahi mahi (dolphinfish) contained less mercury than the FDA concentration limits.

NCCOS scientists presented data at the 17th annual meeting of the American Fisheries Society-Tidewater chapter explaining the reason for the lower mercury levels in the yellowfin tuna. Their research showed that mercury concentrations could be predicted from the mercury concentrations in prey items found in fish stomachs and on the growth and bioenergetics (i.e., the study of the flow and transformation of energy in and between living organisms, and between living organisms and their environment) of the predatory fish. High mercury concentrations are predicted to occur in fish as they approach their maximum size because fish growth slows even while food consumption, with its associated mercury, continues to increase. The mercury bioaccumulation model could be used along with the study of food habits data to predict which other species of fish, and which size classes, would contain high concentrations of mercury.

Synergistic Effects of Pesticides Cause Higher Toxicity than Expected

NCCOS scientists evaluated the combined effects of commonly used agriculture pesticides. The results of a recent NCCOS study suggest that the presence of the pesticides atrazine and chlorothalonil in combination is more toxic to aquatic phytoplankton than each of the toxins separately. This conclusion indicates that aquatic phytoplankton populations may be affected by lower pesticide concentrations than previously thought. These detrimental effects on phytoplankton in turn may reduce nutrient cycling rates and food availability for higher levels of the marine food web. The results of the study complicate risk assessments that had treated the toxicities separately. By characterizing the toxicity of these pesticide mixtures found in coastal waters, NCCOS researchers are helping managers assess risks that these compounds pose to the environment.

Invasive Species Research: Overview

NCCOS' invasive species research activities include providing technical assistance to a growing network of partner interests and conducting complex data analyses, including linking data sets originating from various partners. Non-native plants and animals introduced to the U.S. from other countries or relocated to new areas from within the U.S. can threaten the fabric of coastal ecosystems and cost millions of dollars for management and control. Stimulated by the rapid global expansion of trade, transport, and travel, invasive species and the costs they impose on society are increasing at an alarming rate. After habitat destruction, biological invasion is considered to be the second largest cause of loss of native species and biological diversity.

U.S. marine and coastal environments are particularly susceptible to risks posed by non-native species introductions, as species composition can change in unpredictable, often dramatic ways. Stressed ecosystems face additional risks from invasive species, as the threats posed by those newly introduced species add to stresses already resulting from other factors.

In Hawaii, for example, a recent economic valuation determined that Maui County alone loses $20 million annually as a result of the costs to clean up alien and invasive algae decomposing on beaches, reduced property values, and increased vacation rental vacancies in algae-infested areas. Alien algae are also a major problem in other reef areas across the state, including Waikiki and Kaneohe Bay. They are a major focus of the NCCOS-sponsored Hawaii Coral Reef Initiative Research Program.

Beginning in fiscal year 2002, NCCOS and numerous partners initiated a program to provide coastal managers and the public with up-to-date and scientifically valid information to help them better identify invasive species, warn of new sightings, and predict the likelihood that a particular species may become invasive. In Hawaii, NCCOS scientists initiated a pilot of what eventually is to become a national early warning system to detect the early presence of invasive species in coastal and marine waters.

Invasive Species Research: Overview

With its partners on the Aquatic Nuisance Species Task Force, NCCOS is studying new technologies to help reduce the invasive species impact from ballast water discharges. Other NCCOS research is species-specific, such as examining potential measures to control the spread of the European green crab and the potential impact from the non-native Indo-Pacific lionfish. Best known for its venomous spines, the lionfish has been spotted by divers in increasing numbers off the Carolina coasts. Recent NCCOS studies confirm that the lionfish population is increasing. Research is helping scientists estimate the potential range of the lionfish incursion based on their understanding of temperature tolerance.

Invasive Species Research: Highlights

Hawaiian Pilot System Tests Early Warning Concept for Invasives

With a fiscal year 2002 grant from the Aquatic Nuisance Species Task Force, augmented with additional NOAA funds in 2003, NCCOS has initiated the Hawaiian Pilot Early Detection and Warning System for Coastal Marine Alien Species. With the Bishop Museum in Hawaii and additional partners, NCCOS made significant progress on the pilot system that tests the utility of this prototype for a national system.

Using peer-reviewed taxonomic lists from the American Fisheries Society, the Hawaiian pilot warning system will compare reported sightings against geographic lists reported in the Society's list. Taxonomic experts will verify reported specimen identities, and a subsequent risk assessment will consider the potential for the species becoming invasive, based on consideration of life cycle and environmental tolerances. With its goals of detecting and quantifying the risk, and warning managers before a new alien species spreads beyond its initial introduction site, this initiative will provide coastal managers timely information coupled with options for action. As a result, coastal resource managers will be able to more effectively respond to and mitigate damages from invasive species.

Technical Assistance Provided to Control Green Crab Invasion

With its partners on the Green Crab Management Committee, NCCOS sought public comment on a draft plan to control the European green crab invasion, which continues to plague U.S. waters. *Carcinus maenas*, commonly referred to as the European green crab, is native to northern European coastal waters. Since the early 1800s, when it appeared on the U.S. east coast, it has successfully extended its range as far north as Nova Scotia and as far south as Maryland. Green crabs are known to be voracious predators, and they appear to be responsible for broad-scale changes in invertebrate communities, including commercially important species such as scallops.

Invasive Species Research: Highlights

Technical Assistance Provided to Consider Asian Oyster Introduction

A NCCOS scientist chaired an *ad hoc* panel formed by the U.S. Environmental Protection Agency's Chesapeake Bay Program to review a proposed pilot introduction of a non-native oyster into the Chesapeake Bay. The panel was asked to consider potential economic advantages in the context of uncertain, and potentially risky, effects on the Bay ecosystem. The proposal, submitted by the Virginia Seafood Council to the Virginia Marine Resources Commission, was aimed at determining the feasibility of growing the genetically mated Asian oyster, *Crassostrea ariakensis*, under industry culture conditions, and exploring further aspects of market potential. The panel recommended against the proposal, indicating six concerns associated with risks of introducing an invasive species, and concluded that those risks need to be addressed satisficatorily before the proposal could get further consideration. In addition, NCCOS teamed with federal and non-federal partners to sponsor a study by the National Academy of Sciences (NAS) on the issue. The NAS study supported the panel's recommendations, which have since been incorporated into a potential U.S. Corps of Engineers permit for the proposed activity.

Pacific Invasive Species Discovered Off Carolina Coast

NCCOS scientists discovered an unusual invasive species in 2002 off the coast of North Carolina. *Pterois Volitans*, commonly known as lionfish, inhabits the tropical Pacific Ocean, but was collected multiple times off Cape Hatteras. As part of its invasive species research, NCCOS scientists captured the fish live, cultured it, and studied its environmental tolerances to determine its potential to become invasive and reproduce. Researchers from NCCOS and North Carolina State University collaborated on studies to assess its temperature tolerance, which showed that lionfish can tolerate winter temperatures from the Gulf of Mexico to Cape Hatteras. No lionfish have yet been found west of the southern tip of Florida, but the study results point to the importance of initial introduction locations to the

Photo: A. Meinesz

Invasive Species Research: Highlights

subsequent spread of an invasive species. The NCCOS/North Carolina State University research indicates that managers from the Gulf of Mexico should realize that lionfish are capable of inhabiting their region, even though they have not spread there naturally. The study concluded that coastal management plans in the southeast U.S. need to consider threats posed by lionfish specifically, and by invasive marine fish more generally.

Land and Resource Use Research: Overview

NCCOS conducts and supports research on specific causes and effects of land and resource use on marine ecosystems, helping coastal managers make more informed choices on land use practices. Of particular concern to NCCOS are those ecosystems managed directly and indirectly by NOS, including:

- **Estuaries, including National Estuarine Research Reserves:** NCCOS conducts scientific research in estuaries to support agency mandates for habitat restoration; assess habitat health; and forecast consequences of changing environmental conditions on fisheries, natural resources, and uses of the coastal environment. National Estuarine Research Reserves were created to focus scientific research in the "real world" of estuaries.
- **Coral Reef Ecosystems:** Coral reef ecosystems are complex resources and important in terms of biological diversity, fisheries production, coastal protection, tourism, maritime and cultural heritage, and human sustenance. Coral reef ecosystems are under stress from both natural events (e.g., hurricanes and tropical storms) and human activities (e.g., tourism, fishing, and dredging.) NCCOS is working to understand the extent of, and the reasons for, the decline of coral reef ecosystems and to provide managers better tools to protect and benefit from coral reef ecosystems.
- **National Marine Sanctuaries:** These Sanctuaries have been established in the Great Lakes, the U.S. Exclusive Economic Zone, and states' Territorial Seas to protect the unique biodiversity, sustainability of use, and cultural heritage of certain areas. In each of these areas, NCCOS leads scientifically-based assessments to characterize natural conditions, identify stressors, and forecast future conditions of these special areas. This information is essential for evaluating how current management activities are achieving management objectives.

Land and Resource Use Research: Overview

NCCOS researchers are using new underwater mapping technologies to improve understanding of living marine resource distributions, as well as physical and hydrological features of estuaries and coasts - including areas that have been set aside as marine protected areas. Such mapping provides a baseline of conditions against which future comparisons can be made.

Breakthrough software developed for NCCOS objectively relocates NOAA CoastWatch satellite data to within one pixel (1.47 kilometers) of true location. New image processing technologies permit near real-time monitoring of events, such as shifts in the Gulf Stream and episodes of estuarine turbidity, and permit better interpretations of land-coastal interactions.

Coastal ecosystem studies, such as one underway in the Beaufort-Hilton Head region of South Carolina, are examining links between nutrient and contaminant runoff and population and socioeconomic trends. As a result of these studies, improved understanding of how the trends affect coastal ecosystems is helping local planning officials reduce negative effects of coastal development.

NCCOS and its partners wihin NOAA are producing a multi-volume guidance manual to provide technical assistance in developing and conducting sound scientific monitoring of coastal restoration efforts being done to meet the goals of the Estuary Restoration Act. The draft manual has received strong support from the user community. Such well planned science-based monitoring of coastal restoration offers a way to evaluate the effectiveness of individual projects in meeting project and ecosystem restoration goals, allowing managers to make appropriate mid-course corrections to these projects as needed.

Scientists worked with local volunteers to complete monitoring salt marsh restoration sites in Carteret County, North Carolina. This partnership provided technical expertise to community groups for more effective monitoring and benefitted NOAA through additional habitat restoration. Such efforts also led to cost savings and improved environmental understanding.

Land and Resource Use Research: Highlights

Areas of particular emphasis for land and resource use research are estuaries, coral reef ecosystems, National Marine Sanctuaries and other protected areas, and the effects of land use on living marine resources.

Estuaries

Estuaries and estuarine-like habitats such as the Great Lakes consist of numerous habitat types, including salt marshes, oyster reefs, swamps, and seagrass meadows. Estuaries provide critical habitat for many species of fish, shellfish, and seagrasses. They serve as nursery and spawning grounds for a number of endangered and threatened species. Yet many U.S. estuaries, bays, and large lakes suffer the impacts of multiple anthropogenic stressors.

Societal Values Integrated into Evaluation of Estuarine Health

NCCOS - in partnership with the U.S. Department of Agriculture, U.S. Department of the Interior, and U.S. Environmental Protection Agency - produces a biennial report of the status of U.S. estuaries. In 2003, NCCOS began contributing information to the biennial reports on societal values and how they can be used to prioritize regional ecosystem uses.

Better Predictive Models Improve Land Use Decision-Making in Southeast

Research and analyses of historical data help distinguish between trends caused by natural variability and those resulting from anthropogenic stressors. New modeling capabilities, for example, are improving scientists' abilities to forecast impacts of anthropogenic stressors, such as coliform bacteria and nutrient loads. In 2003, NCCOS scientists used combinations of 14 land use classifications, water quality measurements, and climate factors to model and account for increased variability in estuarine systems. The scientists reported their findings entitled "Preliminary modeling of nutrient and fecal coliform loading into small, urbanized estuarine systems" in January 2003 at the Southeast Coastal Ocean Science Conference in Charleston, South Carolina. These results are leading to improved predictions of coastal development impacts for use by coastal managers in considering land use development alternatives.

Land and Resource Use Research: Highlights

Along with the estuaries themselves, adjacent groundwater is also affected by inputs from local salt marshes and is itself an important input to coastal systems, according to a recent NCCOS-funded study.

Better Modeling Improves Land Use Decision-Making in Mid-Atlantic

Improved models and regional research, such as a recently completed in-depth study of the Patuxent River Estuary in Maryland, are helping scientists and managers address issues associated with nutrient loads, low dissolved oxygen, contaminants, fishing pressure, development, and harvest regulations. A newly developed empirical nutrient discharge model is helping managers predict the effects of various land use scenarios on discharges of water, sediment, organic carbon, silicate, and some forms of nitrogen and phosphorus into the Patuxent River watershed.

This model, developed by NCCOS-funded researchers at the University of Maryland and University of North Carolina, can account for nonpoint source runoff, point sources, and reservoir management. The researchers used several land use scenarios to predict changes in the Patuxent River's nutrient load. One scenario extrapolates population growth and land use development to the year 2020 based on current patterns, zoning, and land use regulations. The model results indicate that changes in available cropland may have more effect on nutrient concentrations than land development changes.

Land and Resource Use Research: Highlights

Seagrasses

Special emphasis is placed on seagrass communities, which are part of both estuarine and coral reef ecosystems. Seagrasses form the basis for highly productive ecosystems – binding sediments, buffering waves and currents, cleansing water column nutrients, and providing food and shelter for other marine organisms, such as fish and their prey. Seagrasses are also a broadly applicable indicator of coastal water quality and ecosystem health. The ecosystem value of seagrasses is well recognized, but many aspects of their distribution, population dynamics, and restorative abilities are not well understood.

Greater Knowledge Improves Seagrass Restoration

In fiscal year 2003, NCCOS researchers field-tested new methods for transplanting seagrass in an effort to increase the size of transplant units and reduce the human effort involved in transplanting. New forecasting tools that predict storm injuries to seagrass beds are helping resource managers identify areas most in need of immediate remediation.

Seagrass studies conducted and sponsored by NCCOS in 2003 have assessed impacts of regional concern - such as boat groundings, orientation and impacts of residential docks, and fishing practices, such as placement of lobster traps.

Land and Resource Use Research: Highlights

Coral Reefs

Coral reefs, among the most valuable and spectacular places on Earth, are also some of the most productive and diverse marine ecosystems. NCCOS' Coral Reef Research Program seeks to protect healthy coral reef ecosystems and reverse degradation of those that have been impaired.

First Integrated Assessment of Coral Reef Ecosystem Published

The first report on the state of coral reef ecosystems identified increasing degradation of shallow-water reefs near inhabited coastal areas. The report pointed to three primary factors responsible for the coral reef damages:

- coastal development and runoff, in the form of turbid water and sediments that bury organisms;
- pollution, including over nutrification and toxic chemicals; and
- overfishing and the impact of fishing gear.

The NCCOS report also noted that many coral reefs distant from inhabited shores are still in pristine condition.

Study Shows Land Use Practices Degrading Hawaiian Coral Reef Ecosystems

Reinforcing these NCCOS findings is a recent study partly funded by NCCOS and published in the journal *American Scientist*. In that study, coral reef experts exposed the dramatic impacts that land-based disturbances can have on coral reef ecosystems. Coral reef conservation efforts, the study concludes, will have only limited success unless problems originating from land practices are addressed.

The effects of land use practices on coral reef ecosystems are shown in a study sponsored by Hawaii's Coral Reef Initiative and funded in part by NCCOS. Waimanalo Stream is one of the most seriously polluted waterbodies in Hawaii, with an estimated 42 percent of its streambed choked with dense grass and a significant portion hardened with concrete. Preliminary results show the flat concrete

bottom of the stream heats up and destroys vertebrates and invertebrates that make up part of the stream's life cycle. The ecology of the stream is damaged to the extent that it no longer behaves like a sponge, soaking up rainwater and releasing it slowly during dry weather. Instead, runoff pushes everything into the ocean, depositing pollutants in near-shore waters and on reefs.

New Technologies Improve Coral Ecosystem Mapping and Health Assessments

Technology innovations are expanding NCCOS scientists' ability to understand water quality impairment and risks to coral reef ecosystems. Increasingly, the scientists can gather information about water depths and coral reef coverage from various sensors, including satellite imagery. In addition, advances in aerial photography, global positioning system (GPS) orientation, and underwater photography are providing a clearer picture of submerged coral, seagrass, and algal communities and providing a baseline against which changes in coral reefs can be monitored. A new technology called fluorescence photography is being evaluated by NCCOS researchers as a simple, rapid, and non-invasive way for coastal managers to measure recovery of damaged coral sites.

Further contributing to the overall effort to improve understanding of the nation's shallow-water coral reef resources, NCCOS is leading a multi-agency federal effort to map distribution of coral reefs throughout U.S. states and territories, and to complete that mapping effort by no later than 2007. NCCOS experts are optimistic that advances in technology may allow them to complete that essential mapping activity even earlier than the planned 2007 target.

Improved Knowledge Aids Coral Ecosystem Restoration

In better understanding the extent of and reasons for coral reef ecosystem declines, NCCOS and its research partners are providing coastal resource managers new knowledge for protecting and restoring those ecosystems. Their research is showing that several factors, such as heavy algal growth, depleted herbivore fish populations, and a lack of active sexually reproducing corals, often interact to prevent the re-growth of degraded coral habitats.

Land and Resource Use Research: Highlights

Despite scientific and conservation efforts to support replenishment of herbivore fish populations, coral reef recovery in some protected areas remains elusive. NCCOS scientists suspect that coral regeneration is being hampered in some cases by a lack of active sexually reproducing coral populations. One result is a diminished pool of new colonizing coral larvae. Scientists working in the NCCOS-sponsored Puerto Rico Coral Reef Monitoring Program are looking at the role that coral farms can play in augmenting the larval pool to enhance coral recovery. Their goal is to create new coral colonies to act as "seed" banks, ultimately accelerating coral recovery over a larger area of the reserve.

National Marine Sanctuaries and Other Protected Areas

Marine protected areas protect key habitats and promote sustainable use of marine resources. These protected areas function as a fishery management tool by protecting a species during life stages especially vulnerable to human activities, and protecting areas that supply fish to non-protected areas.

NCCOS surveys of marine life, fish distribution studies, and spawning studies are helping fisheries planners and National Marine Sanctuary staff determine placement of new protected areas and evaluate the effectiveness of existing ones. Species-specific spawning location, larval transport, and the dynamics of juvenile fish recruitment are all important areas of study. For protected areas to contribute to fish populations in other areas, they must supply fish to these other areas. Fish otolith research by NCCOS and its partners helps to quantify the proportion of larvae that are locally retained around natal coral reefs. Other studies look for changes after establishment of reserves, to determine the efficacy of those reserves - whether, for example, corals are re-establishing themselves at rates comparable to those of a decade earlier.

Characterizations Help Manage Sanctuaries

NCCOS, in cooperation with NOAA's National Marine Sanctuary Program (NMSP), completed a biogeographic assessment of North / Central California sanctuaries. The study determined biogeographic patterns of selected marine fishes, birds, and mammals found within and adjacent to the Cordell Bank, Gulf of the Farallones, and Monterey Bay National Marine Sanctuaries. The assessment results will be used by the NMSP in formulating and implementating sanctuary management plans.

Land and Resource Use Research: Highlights

Data Support Protective Value of Reserve

Another research project examined the efficacy of the Tortugas Ecological Reserve designation as a Marine Protected Area. Survey work conducted by researchers from NCCOS and three other institutions is helping scientists and policy makers document changes and determine the efficacy of the Tortugas Ecological Reserve. The researchers conducted approximately 200 dives at permanently established stations located between coral and sand/seagrass ecosystems. The dives led to the updating of temperature recorders. The divers measured fish abundance and composition, coral health, bottom cover and roughness, benthic primary production, and seagrass and algal abundance. They also re-surveyed stable isotopic signatures of selected organisms to identify food webs supporting the ecosystem. They recorded side-scan sonar of study sites, water column productivity, and water clarity. They also compared the recovery of closed areas with areas still fished by the pink shrimp fishery. Results strongly support the hypothesis that non-coral habitat areas adjacent to coral reefs are the source of nutrients that fuel the reef ecosystem. This supported the decision by the Florida Keys National Marine Sanctuary to close areas adjacent to the coral reefs to shrimp trawling to ensure the productivity and integrity of the coral reef environment.

NCCOS Research Critical in Determination of Damage Settlement Award

Managing motor vessel impacts to seagrass meadows is a significant problem facing resource managers in the Florida Keys National Marine Sanctuary. A special issue of the *Journal of Coastal Research* highlighted NCCOS applied research for use in mediating damages from vessel groundings. This research has been used in litigation and in developing and implementing the seagrass Damage Assessment and Restoration Program in the Florida Keys National Marine Sanctuary. The scrutiny of peer review and publication in a reputable scientific journal helps ensure that information used in litigating and recovering financial damages from vessel impacts meets legal standards for evidence and expert testimony.

Local managers have used data from NCCOS surveys of sanctuaries and protected areas to select sites for boat moorings and recreational activities that help minimize

Land and Resource Use Research: Highlights

negative impacts on resources. The local managers help NCCOS decide which studies are best suited and most needed in their regions, helping meet one of NCCOS' underlying goals of supporting resource managers.

Researching Land and Resource Use Impacts on Living Marine Resources

NCCOS researchers are investigating how changes in land use and management patterns, population growth, habitat quality, and other environmental factors affect fisheries and other living resources. For instance, a 2000 NOAA Fisheries assessment found that many fish stocks are in decline, despite efforts to manage them for sustainable use. Specifically, of the 905 fish stocks in the U.S. EEZ, 72 are overfished, five are approaching overfished status, and 210 are not overfished. The status of the remaining 618 stocks is virtually unknown.

New Technologies Improve Manager's Capabilities to Protect Resources

Multiple tools are required to equip fisheries managers with the ability to manage species inhabiting diverse environments during their life history. For example, researchers at East Carolina University teamed with NCCOS scientists to use genetic profiling and otolith microchemistry to provide new knowledge of life history strategies of striped bass in North Carolina and Nova Scotia. Genetic positioning is also being used to stop the illegal trade of endangered species. Improved models are also being developed to aid fisheries managers in better managing and protecting natural resources.

NCCOS researchers are also developing new and improved tools to help track and prosecute those who seek to profit from the capture of endangered species by identifying sea turtle eggs and cooked meat by individual species. All sea turtle species are endangered or threatened, but despite protection by U.S. and international law, they are still poached for consumption and handicrafts.

Earlier species identification methods had been useful only for fresh muscle tissue and did not aid in cases where eggs were seized or where meat was cooked (i.e., if seized for use in restaurants). The new DNA-based method for identification of cooked and raw meats, eggs, and trace evidence such as blood offers a powerful

new tool for sea turtle conservation, and provides law enforcement with the scientific capability to prosecute poachers. NCCOS research in this area has recently been published in the journal *Conservation Genetics*.

Everglades Restoration May Have Unexpected Consequences to Fisheries

Of particular concern to some fisheries managers is the planned Everglades restoration project, which will alter freshwater flows in the region and may alter the salinity and temperature of the water as well. Results of a recent NCCOS study indicate that water temperature and salinity affect the feeding behavior of juvenile gray snapper, an important fishery species in South Florida.

A cooperative project between NCCOS and the South Florida Water Management District has shown that a region of high mercury concentrations in fish persists in eastern Florida Bay where freshwater from the Everglades enters the Bay. Project data indicate that the source of the high mercury concentrations is not only freshwater runoff (which might change during Everglades restoration), but also sites within the Bay and its fringing mangrove margin where active methylation of inorganic mercury occurs.

Model Provides Capability for Determining Possible Hypoxia Effects on Larval Fish

Species-specific models are being developed to describe the vertical distributions of larval fishes in the northern Gulf of Mexico. Modeling offers an explicit approach to understanding how changes in the northern Gulf of Mexico ecosystem affect survival of early life history stages of fishes, and ultimately the dynamics of adult populations. The Gulf of Mexico studies model larval fish survival as a function of environmental forcing (e.g., hypoxia events, river plume effects, vertical mixing, and physical transport). Data collected at a stratified, hypoxic station and a vertically well-mixed station provide new insights on how these different physical regimes affect the vertical distribution of larval fishes. These and other studies will hopefully provide insight into the potential effects of this hypoxic region on fisheries production.

Land and Resource Use Research: Highlights

Land and Resource Use Research: Highlights

Marine Mammals Serve as Sentinels of Ecosystem Health

Exploring possible links between environmental stressors and health threats to marine organisms is another research area addressing land and resource use effects on the coastal environment and its resources. In Indian River Lagoon, Florida, scientists were concerned over the high level of dolphin strandings and observations that more than 30 percent of the Lagoon's 500 dolphins exhibit unexplained skin lesions.

The first comprehensive bottlenose dolphin health assessment was completed in July 2003 by NCCOS scientists, experts at the Harbor Branch Oceanographic Institution and partners at Indian River Lagoon. The project sought to identify serious health threats and identify links to possible environmental stressors. The Health and Risk Assessment Dolphin Project team captured and safely released 42 dolphins during the two-week study. Prior to their release, the scientists conducted comprehensive health examinations, clinical health measurements, immunological profiles, and contaminant measurements.

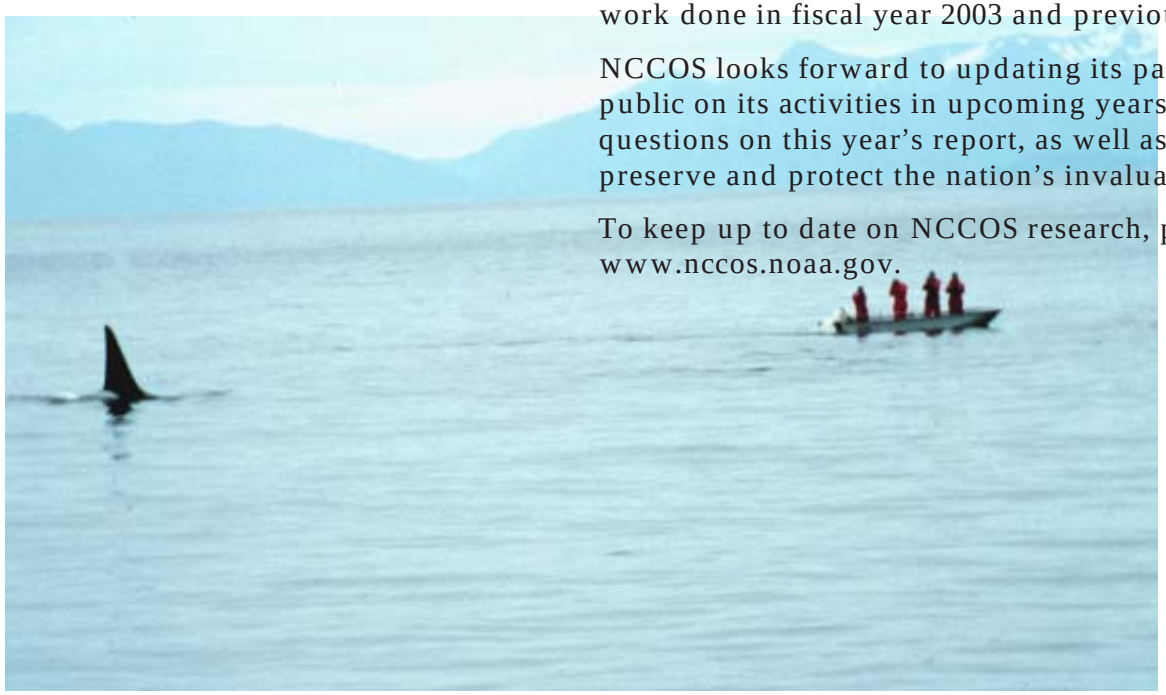
The bottlenose dolphin health assessment provides the first opportunity to examine the animals closely and relate health conditions and habitat. Parallel dolphin health studies were also underway in Charleston, South Carolina in August 2003 to establish baseline measurements. Data from this five-year assessment will allow scientists to compare two distinct populations and correlate environmental factors that may influence dolphin health.

The Year in Review... and Looking Ahead

Only through long-term interdisciplinary studies will scientists be able to better understand, assess, and predict ecological and living marine resources.

This NCCOS Annual Accomplishments Report, the second such report completed since NCCOS was established in 1999, highlights scientific research activities in fiscal year 2003. It seeks to provide highlights of and insights into the scope of NCCOS' research activities, but it cannot possibly go into great detail on each individual activity.

Scientific research, of course, does not merely begin on one arbitrary date and magically come to a conclusion 365 days later. Instead, the work discussed in this Accomplishments Report had its origin in some cases years earlier, and it built on existing and ongoing NCCOS scientific research. Similarly, the scientific progress to be reported in upcoming NCCOS accomplishments reports is the inevitable result of work done in fiscal year 2003 and previously.



NCCOS looks forward to updating its partners, constituencies, and the general public on its activities in upcoming years. NCCOS welcomes your comments and questions on this year's report, as well as your involvement in its ongoing efforts to preserve and protect the nation's invaluable coastal ocean resources.

To keep up to date on NCCOS research, please visit our web site at www.nccos.noaa.gov.

NCCOS Headquarters

NCCOS Headquarters (NCCOS HQ) is located in Silver Spring, Maryland, where its parent organization, the National Ocean Service, is headquartered along with the National Oceanic and Atmospheric Administration. Headquarters operations include professional, financial, and administrative management and coordination of all the activities conducted at the five NCCOS Centers addressing national coastal ocean priorities.

NCCOS Headquarters (NCCOS HQ)
1305 East West Highway, Room 8110
Silver Spring, Maryland 20910
Phone: (301) 713-3020
Fax: (301) 713-4353
http://www.nccos.noaa.gov

The Center for Coastal Monitoring and Assessment (CCMA)

The Center for Coastal Monitoring and Assessment (CCMA), located in Silver Spring, Maryland, monitors, surveys, and assesses coastal environmental quality, habitats, and resource distribution. CCMA manages the National Status and Trends Program, involving long-term contaminant monitoring at more than 350 estuarine and coastal sites. The monitoring and assessment studies determine how contaminant exposure and changes in coastal habitats will affect the distribution and abundance of living marine resources. In addition, CCMA uses remote-sensing technology to evaluate estuarine and coastal environmental problems, track harmful algal blooms, and determine coastal habitat changes over time.

Center for Coastal Monitoring and Assessment (CCMA)
1305 East-West Highway, Room 8419
Silver Spring, Maryland 20910
Phone: (301) 713-3028
Fax: (301) 713-4388
http://www.ccma.nos.noaa.gov

The Center for Coastal Environmental Health and Biomolecular Research (CCEHBR)

The Center for Coastal Environmental Health and Biomolecular Research (CCEHBR), in Charleston, South Carolina, conducts interdisciplinary research on issues related to coastal ecosystem health, environmental quality, and related public health impacts. CCEHBR (pronounced see-ber) conducts chemical, biomolecular, microbiological, and histological research pertaining to human influences on marine and estuarine habitats. The affiliated Oxford Cooperative Laboratory, in Oxford, Maryland, specializes in pathology of marine organisms and habitat restoration research.

Center for Coastal Environmental Health and Biomolecular Research (CCEHBR)
219 Fort Johnson Road
Charleston, South Carolina 29412-9110
Phone: (843) 762-8525
Fax: (843) 762-8700
http://www.chbr.noaa.gov

The Center for Coastal Fisheries and Habitat Research (CCFHR)

The Center for Coastal Fisheries and Habitat Research (CCFHR), in Beaufort, North Carolina, provides coastal resources managers with information to enhance recreational and commercial fishing and essential fish habitat. CCFHR (pronounced see-fer) conducts laboratory and field research on estuarine processes, near-shore and ocean ecosystems' biological productivity, dynamics of coastal and reef fishery resources, and effects of human influences on resource productivity. Kasitsna Bay Laboratory, located on a small bay in the Kachemak Bay system in Alaska, is affiliated with CCFHR.

Center for Coastal Fisheries and Habitat Research (CCFHR)
101 Pivers Island Road
Beaufort, North Carolina 28516
Phone: (252) 728-3595
Fax: (252) 728- 8784
http://shrimp.ccfhrb.noaa.gov

The Center for Sponsored Coastal Ocean Research (CSCOR)

The Center for Sponsored Coastal Ocean Research (CSCOR), located in Silver Spring, Maryland, administers a federal-academic partnership to develop predictive capabilities for managing coastal ecosystems. These partnerships support long-term, multidisciplinary projects to evaluate ecological effects of multiple stresses; develop forecasting tools; respond to the combined public health, economic, and ecosystem threats from harmful algal blooms; and, transition successful research into NOAA operations. Major CSCOR (pronounced see-score) research areas address coastal fisheries ecosystems, cumulative coastal impacts, and harmful algal blooms/ eutrophication.

Center for Sponsored Coastal Ocean Research (CSCOR)
1305 East West Highway, Room 8307
Silver Spring, Maryland 20910
Phone: (301) 713-3338
Fax: (301) 713-4044
http://www.cop.noaa.gov

Hollings Marine Laboratory (HML)

A new center (yet to be named) will be housed at the Hollings Marine Laboratory (HML) in Charleston, South Carolina. The multi-institutional, multidisciplinary laboratory focuses on the relationship between the coastal ocean ecosystem and human health. It represents an innovative way of developing scientific advancements by integrating medical and marine expertise through a diverse partnership among federal, state, and academic interests. Partnering Institutions are NOAA/ NOS/ NCCOS , Medical University of South Carolina, National Institute of Science and Technology, University of Charleston, and South Carolina Department of Natural Resources.

Hollings Marine Laboratory (HML)
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Phone: (843) 762-8811
Fax: (843) 762-8737
http://www.nccos.noaa.gov/about/hml.html